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14. ABSTRACT

This report summarizes the accomplishments of the Laboratory for Computational Cultural Dynamics (LCCD) from May 2005 through May 2008.

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Accomplishments

1. Extracting Cultural Contextual Data

When developing models about a given culture (e.g. the *Afridi* tribe in Pakistan), we need to extract all possible information about the context in which that tribe is functioning. This context includes accessing a wide variety of data sources including news sources, economic data, political data, religious data, demographic data, historical data, and event data.

We developed the theory and algorithms needed to improve our ***STORY*** system for extracting information from diverse text documents. For example, the STORY system can extract data from documents in the form of RDF triples – RDF is a World Wide Web Consortium standard for representing knowledge. In our work in the LCCD project, we:

- Initiated efforts to assign a *time-stamp* to the data extracted by STORY. This is critical as we would like to know when certain events reported in one or more documents occurred. For example, to build the cultural context of the Afridi tribe today, we need to understand not only what events occurred in the past, but when.
- We developed an initial prototype for assigning such time stamps within STORY. This is still an initial prototype – we are continuously improving it.
- We have expanded the previous version of the STORY system to extract data relevant to Pakistani tribes – in particular, we have started focusing on the Afridis.

The STORY system described above was one of 28 honorees in *ComputerWorld* magazine's 2005 Horizon Awards. Of several hundred nominations, eight were selected to be winners and there were 20 honorable mentions. STORY was one of the honorable mentions – a brief article on it appears in the Sep. 12, 2005 issue of *ComputerWorld.*

2. Opinion Analysis

We developed methods to analyze opinions on diverse topics from news sources in Pakistan. Prior to this work, we had developed quantitative algorithms to assess the intensity of opinion on a given topic on a -1 to +1 scale. In this scale, +1 denotes a very positive article (w.r.t. a given topic), while -1 denotes an article that is very negative about a given topic.

The problem with this was that it was not always apparent how a number translated to a qualitative opinion. For example, when the system assigned a score of -0.2, did this signify "neutral" or "mildly positive"?

During the LCCD project, we developed the following opinion analysis techniques:

- We showed how, given any *qualitative* scale for scoring opinions (e.g. very negative-negative-neutral-positive-very positive), we can assign a qualitative rating for any of the numeric scores.
- We also showed how to assess opinion in *Spanish* language sources language sources in order to enable study of groups such as the *Basques* (see below).

3. Building Cultural Databases

We developed a schema for tribal data. This was done via a combination of two factors: what kind of tribal data are people (military personnel in particular) interested in? And what kinds of such data stand a reasonable chance of being automatically extracted? We identified a combination encompassing the answers to these two questions.

As little tribal data is available worldwide, we developed algorithms building on top of STORY to extract some of these variables, but not others.

4. Learning Behavioral Models in the Presence of Noise

We developed an algorithm called the Derived Belief Strategy (DBS), which builds behavioral models to predict how other agents will behave in the future, by analyzing the agents' behavior in the past. An important problem is how to deal with *noise*, i.e., the possibility that some of an agent's actions may be misinterpreted to be something other than what the agent actually intended. To deal with this problem, we developed an innovative *symbolic noise filtering* technique that DBS uses to determine which of an agent's actions are deliberate and which of them are due to noise.

We entered DBS as a contestant in Category 2 of the recent 20th-anniversary Anniversary Iterated Prisoner's Dilemma Competition (see http://www.prisoners-dilemma.com). Category 2 involved noise in the data, i.e., there was a nonzero probability that a signal to cooperate or defect could be misinterpreted to mean the opposite of what was intended. Out of 165 programs that were entered into this category of the competition, DBS had the third-highest score. Furthermore, DBS was the best-performing of all of the non-master-slave contestants[1] in the competition.

5. Synthesis of Strategies from Interaction Traces

We developed algorithms to take a set of interaction traces produced by different pairs of players in a two-player repeated game, and combine them into a composite strategy. We proved that our algorithm can, in polynomial time, can generate the best such composite strategy. We developed an algorithm to incorporate the composite strategy into an existing agent, as an enhancement of the agent's original strategy.

We did experimental studies of our algorithms using interaction traces from 126 agents (most of them written by students as class projects) for the Iterated Prisoner's Dilemma, Iterated Chicken Game, and Iterated Battle of the Sexes. We compared each agent with the enhanced version of

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[1] Each participant in the competition was allowed to submit up to 20 programs as contestants in the competition. Some participants took advantage of this to submit collections of programs that worked together in a conspiracy in which 19 of the programs (the *slaves*) worked to give as high a payoff as possible to the 20th program (the *master*). In contrast, DBS is not a master-slave program. Instead, DBS builds behavioral models of the other contestants in order to cooperate with them as effectively as possible.

that agent produced by our algorithm. The enhancements improved the agents' scores by about 5% in the IPD, 11% in the ICG, and 26% in the IBS, and improved their rank by about 12% in the IPD, 38% in the ICG, and 33% in the IBS.

6. Workshops and Conferences Initiated

Workshop on Decision Making in Adversarial Domains

Researchers in several different disciplines -- AI, OR, Control Theory, and Economics -- are doing research on adversarial decision-making. The approaches and techniques (game tree search, Markov decision processes, dynamic decision networks, and so forth) appear to have some substantial similarities, but the similarities and differences are ill-understood because the relevant research communities are nearly disjoint.

During 23–25 May 2005, we held the *Workshop on Decision Making in Adversarial Domains*. The purp;ose of the workshop was to compare and contrast the various approaches and assumptions used by the different research communities, in order to develop a better understanding of the relationships. There were approximately 52 participants, from the military, universities, and industry. Further information about the workshop is available at http://www.cs.umd.edu/~nau/adversarial

First International Conference on Computational Cultural Dynamics

Computer technology is leading to sweeping changes in how we can reason about groups in diverse cultures. Examples include computer systems to aid researchers in gathering data about different cultural groups, learning the intensity of opinions that those groups have on various topics, building/extracting models of behavior of those groups, and continuously refining those behaviors through shared, multi-person, learning experiences.

These developments are inherently cross-disciplinary, blending the behavioral and social sciences—fields such as political science, psychology, journalism, anthropology, and sociology—with technological fields such as computer science, computational linguistics, game theory, and operations research.

Historically, many of these research communities have been largely unconnected. To bring them together to help forge a common understanding of principles, techniques, and application areas, we inaugurated a new annual international conferenced, the International Conference on Computational Cultural Dynamics (ICCCD). The first of these conferences was held in College Park, MD in August, 2007. Further information about the conference is available at http://www.umiacs.umd.edu/conferences/icccd2007.

7. Publications

Archival publications published during the reporting period:

1. M. Albanese, V. Moscato, A. Picariello, V.S. Subrahmanian, O. Udrea. Detecting Stochastically Defined Activities in Video, Proc. IJCAI 2007, pages 1802—1807, Jan. 2007, Hyderabad, India.
2. T.-C. Au, U. Kuter, and D. S. Nau. Planning for interactions among autonomous agents. In International Workshop on Programming Multi-Agent Systems (ProMAS), 2008, Invited paper, to appear.
3. T.-C. Au, U. Kuter, and D. Nau. Web service composition with volatile information. In Proceedings of the International Semantic Web Conference (ISWC), 2005.
4. T.-C. Au and D. Nau. Accident or intention: That is the question (in the iterated prisoner's dilemma). In *International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2006.
5. T.-C. Au and D. Nau. Is it accidental or intentional? a symbolic approach to the noisy iterated prisoner's dilemma. In G. Kendall, X. Yao, and S. Y. Chong, editors, *The Iterated Prisoners Dilemma: 20 Years On*, pp. 231–262. World Scientific, 2007.
6. T.-C. Au and D. Nau. Reactive query policies: A formalism for planning with volatile external information. In *IEEE Symposium on Computational Intelligence and Data Mining (CIDM)*, pp. 243–250, 2007.
7. T.-C. Au, D. Nau, and S. Kraus. Synthesis of strategies from interaction traces. In International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), May 2008.
8. F. Benamara, C. Cesarano, A. Picariello, D. Reforgiato, V.S. Subrahmanian. Sentiment Analysis: Adverbs and Adjectives are Better than Adjectives Alone, Proc. 2007 Intl. Conf. on the Web and Social Media, pages 203—206, Boulder, CO, March 2007.
9. R. Carr, E. Raboin, A. Parker, and D. Nau. Balancing innovation and exploitation in a social learning game. In AAAI Fall Symposium on Adaptive Agents in Cultural Contexts, Nov. 2008, To appear.
10. R. Carr, E. Raboin, A. Parker, and D. Nau. When innovation matters: An analysis of innovation in a social learning game. In International Conference on Computational Cultural Dynamics (ICCCD), Sept. 2008.
11. C. Cesarano, A. Picariello, D. Reforgiato, V.S. Subrahmanian. OASYS 2: An Opinion Analysis System, Proc. 2007 Intl. Conf. on the Web and Social Media, pages 313-314, Boulder, CO, March 2007. **This is just a short demo description.**
12. S. Khuller, V. Martinez, D. Nau, G. Simari, A. Sliva, and V. Subrahmanian. Finding most probable worlds of probabilistic logic programs. In International Conference on Scalable Uncertainty Management (SUM 2007), Oct. 2007.

13. U. Kuter, D. Nau, M. Pistore, and P. Traverso. Task decomposition on abstract states, for planning under nondeterminism. Artificial Intelligence, 2008, To appear.

14. U. Kuter, D. Nau, E. Reisner, and R. Goldman. Conditionalization: Adapting forward-chaining planners to partially observable environments. In ICAPS 07 Workshop on Planning and Execution for Real-World Systems, Sept. 2007.

15. U. Kuter, D. Nau, E. Reisner, and R. Goldman. Using classical planners to solve nondeterministic planning problems. In Proceedings of the International Conference on Automated Planning and Scheduling (ICAPS), Sept. 2008.

16. D. Nau. Current trends in automated planning. AI Magazine 28(4):43–58, 2007.

17. A. Parker, D. Nau and V.S. Subrahmanian. The Role of Imperfect Information, in "Adversarial Reasoning: Computational Approaches to Reading the Opponent's Mind" (eds. A. Kott and W.M. McEneaney), pages 209—229, Chapman and Hall, 2006.

18. A. Parker, F. Yaman, D. S. Nau, and V. S. Subrahmanian. Probabilistic go theories. In Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI), pp. 501–506, 2007.

19. V. Subrahmanian, M. Albanese, M. V. Martinez, D. Nau, D. Reforgiato, G. I. Simari, A. Sliva, O. Udrea, and J. Wilkenfeld. CARA: A cultural-reasoning architecture. *IEEE Intelligent Systems*, March/April 2007.

20. V.S. Subrahmanian and L. Amgoud. A General Framework for Reasoning about Inconsistency, Proc. IJCAI 2007, pages 599-604, Jan. 2007, Hyderabad, India.

21. F. Yaman, A. Parker and V.S. Subrahmanian. Probabilistic Go-Theories, Proc. IJCAI 2007, pages 501-506, Jan. 2007, Hyderabad, India.